

# 19

## LANs and topology

Ever since the invention of the telephone enabled us to speak to someone in the next town and the television spawned a remote control, we have been unhappy about the thought of getting out of our chair to communicate with anyone or anything.

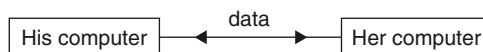
It is a natural progression to apply the same thoughts to our computers and other forms of data communications.

As computers have become more compatible, it seemed a good idea to exchange information by a cable connecting two or more systems. This made it possible to have shared facilities, whether it be massive storage areas, printers or software. It also allows staff to work on the same project and share the corporate facilities.

Sharing data is called networking and is categorized by the physical area that is interconnected. The smallest subdivision is called a 'Local Area Network' or LAN.

A LAN can be as small as you like, as in Figure 19.1 or, more realistically, it could interconnect a whole building or a collection of buildings, or a large manufacturing site or a university with several thousand connections.

**Figure 19.1**  
The smallest  
LAN



### Characteristics of a LAN

- 1 A LAN uses a privately owned communication system rather than the normal telephone system.

- 2 It can operate at high data rates.
- 3 All computers can initiate the transfer of data to any other one.
- 4 LANs generally save costs by sharing costly equipment, software or data libraries.
- 5 LANs improve productivity and allow the exchange of data to be monitored for security purposes.

A whole city can be interconnected or possibly several LANs can be joined to provide a larger system and, in this case, the network is referred to as a MAN, 'Metropolitan Area Network'. Any larger network is called a 'Wide Area Network' or WAN.

## **What bits of hardware are we likely to meet in a LAN?**

### **Communication route**

This will almost certainly be a set of cables. The cables used are chosen to meet the requirements of the LAN, principally a matter of distance and the data rate. The cables used are optic fiber, copper twisted pair and copper coaxial cable. More and more LANs are using wireless communication links which can range from very short distance up to several kilometers. It would seem that wireless LANs do not entirely replace cabled networks but rather add flexibility at the edges of a cable system.

### **Servers**

A server supplies a facility to the network. The name comes from the idea of the device 'serving' the needs of the network.

A typical example may be a 'print server'. Instead of supplying maybe a hundred mediocre quality printers to all the staff, we may decide to have a single super high quality printer that can handle all the printing requirements with better quality, higher speed and less expense.

All LANs have a 'file server'. This device controls access to all the shared files, to store the files when not in use, and to prevent two people modifying a file simultaneously. Having the files held centrally means that we can wander off to another part of the building and can use any computer to access the previously used files. There are two more advantages. If the software needs upgrading, there is only a single copy to be loaded. Backing up the work is easy since all the shared files are held on the file server. Once all the staff have gone home at night, the server can carry out a backup of the day's work before going to sleep.

If we want to access an external network, we can make contact via the normal telephone communication system by using a modem like the one we use with the Internet or, as more likely for an organization, a dedicated line with a router connected to a broadband link. As with the print server, it is more economic for a 'communication server' to control a series of modems than to provide each staff member with their own modem.

## Connecting our computer to a network

To connect our computer to a network we need to install network interface cards (NICs). The power is switched off, the case of the PC is taken off, and the card inserted into one of the expansion slots. The software is run to make sure the computer will be recognized by the network and the case is put back on again. Done. We are now part of the club.

## Topology at last

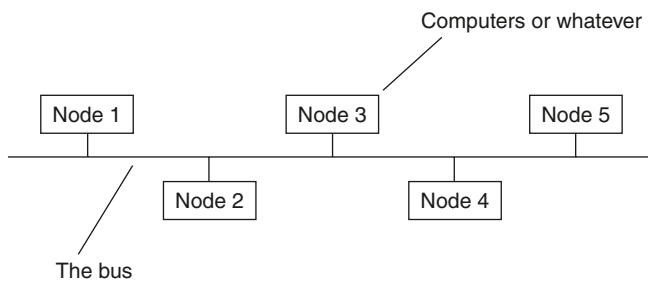
We have choices when it comes to how we connect several computers and other devices. These connection patterns are what we call *topology*, an impressive name for something quite simple.

There are only three basic designs from which all other layouts are derived. Just before we start, we should mention the term 'node'. This is the name given to any piece of equipment that can be connected to a network, such as computers, terminals or printers.

## Bus topology

Here is the first design and probably the most obvious. We have a length of optic fiber or copper cable and connect all the nodes, one after another. This layout is shown in Figure 19.2 but in reality the bus does not need to be straight, it simply wanders around connecting to each of the nodes.

**Figure 19.2**  
Bus topology



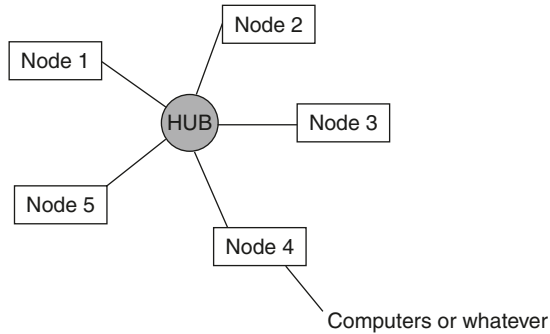
Bus topology is very simple to construct and can be expanded simply by joining new devices to the bus cable. If the bus cable is damaged, the whole network may fail and your whole workplace goes for a coffee break until it is fixed, which may take some time. We can get over this reliance on a single cable by using star topology but this brings its own problem, as we will see.

## Star topology

In this design, we have a central connection called a *hub*. This is a central computer or server that is connected to each node as in Figure 19.3.

The central hub asks each node in turn whether it has a message to send. If a node, say node 2, wishes to send data to node 5, it says 'yes' and sends it to the hub which then re-routes it to node 5. The hub goes on to check with node 3, then 4

**Figure 19.3**  
Star topology



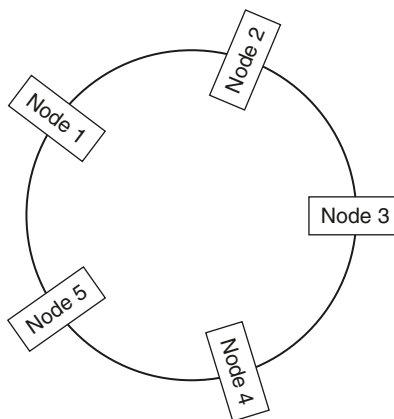
and so on. Providing the hub is fast enough it can handle all routing requirements. It can do more than this; it can provide the management with details of who is sending what data to whom.

As each node can be easily disconnected without interfering with the whole system, faults can be isolated more easily. The snag is that if the hub fails, the whole system goes down.

### Ring topology

This is a modified version of the bus topology. The two ends of the bus are simply joined together to form a ring as shown in Figure 19.4.

**Figure 19.4**  
Ring topology



If node 2 wishes to send a message to node 5, a system of tokens is used. A token is a short electronic code that is passed from node to node round the ring. Node 2 waits until it receives the token then attaches its message and an address. The token, message and address are passed to node 3, then 4, then 5. Node 5 recognizes the address and removes the attached message and the token continues around the ring until someone else wants to send some data.

There are a couple of problems with this system in that a failure of any node will stop the rotation of the token and the whole network will fail immediately.

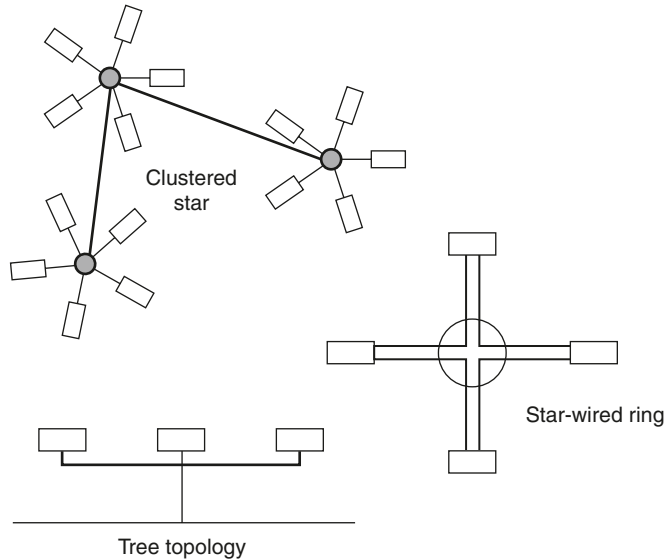
Expanding the network by adding another node is only possible if the ring is broken and the network is shut down.

### Hybrid topologies

We can use the three basic topologies in combination with each other to create a large number of possibilities as required in the network being installed.

Three popular hybrids are illustrated in Figure 19.5.

**Figure 19.5**  
Hybrid  
topology



The first is called the *clustered star topology*. To do this we start with a bus and instead of separate nodes we can connect star clusters.

*Tree topology* also starts with the bus system but reduces the length of cable used by combining some of the routes.

*Star-wired ring* is, as the name suggests, a combination of the ring and the star. The nodes pass through the hub before going onto the ring to pass the data its destination. The hub can also disconnect a faulty node and allow the system to remain operative.

As can be imagined, there are many amazing possibilities but if we are aware of the basic patterns we will be able to find our way around the others.

### Ethernet

There have been many pretenders to the throne of king of Local Area Networks but without doubt it is Ethernet that has won the crown.

In the last ten years there was competition between;

- 1 Token ring: a ring as described in the topology section above and using copper or fibre.

- 2 FDDI (Fiber Distributed Data Interface): a dual redundant fiber optic ring that also briefly had a copper version, CDDI.
- 3 ATM (Asynchronous Transfer Mode): A high-speed fiber network designed mostly for telecoms but touted for a while in a LAN variant in copper and fiber.
- 4 Fiber Channel: a fiber system designed mostly for high-speed links between storage devices in the so-called Storage Area Network (SAN), market. Seen here also was the IBM ESCON (Enterprise System Connectivity) system which even spawned its own special fiber connector.
- 5 HIPPI, SCSI, Starlan, USB and so on.

For everyday office connection, however, Ethernet reigns supreme.

Ethernet started as a 10 Mb/s LAN using a thick coaxial cable in a bus topology. A 10 Mb/s fiber link was established as well to link different segments of the coaxial cable together.

Around 1992 a star-wired version was introduced using a simple twisted pair copper cable from which the Category 3 cable standard evolved. This star-wired concept using twisted pair cables can be said to be the foundation of the structured cabling model we still use today.

The 10 Mb/s system is still prevalent today but has been overtaken in shipments by the 100 Mb/s copper version, which also has a fiber optic version. For many years the most common LAN/cabling model was 10 Mb/s Ethernet to the desk on copper Cat 5 cable with an optical fiber backbone (usually 62.5/125) running 100 Mb/s to link the floors together.

The next stage was gigabit Ethernet. Two fiber versions of this exist to link up the backbones of the larger campus network, but there is also a copper Cat5/Cat 6 version.

Ten gigabit Ethernet is now with us. Surprisingly there is a copper version of this as well but limited to 100 m runs. There are a number of fiber versions: a low cost VCSEL system to be used on the new OM3 fiber up to 300 m; a heftier laser system for many kilometers' transmission; and a wavelength division multiplexing system for use on bandwidth-limited old multimode fiber. There is also, for the first time in LAN technology, a 1550 nm system that can transmit up to 40 km in one hop. Optical Ethernet now makes the Local Area Network look very big indeed.

Table 19.1 summarizes the whole Ethernet family.

On a final note: optical fiber has always been promoted as a futureproof technology due to its range and bandwidth compared to copper cable. However, if we look at the most prevalent premises/campus optical fiber of the 1990s, i.e. 62.5/125, we can see that it can happily send 100 Mb/s over 2000 m – state of the art in the nineties, but when somebody comes along and plugs their new 10 Gb/s Ethernet box into it, that transmission distance comes down to just 26 m, hardly making it out of the equipment room!

Things will always change. . . .

**Table 19.1**

Ethernet family	Speed	Media	Range
10BASE-5	10 Mb/s	Coax	500 m
10BASE-2	10 Mb/s	Coax	185 m
10BASE-FL	10 Mb/s	mm fiber	2000 m
100BASE-T	100 Mb/s	Cat 5	100 m
100BASE-T4	100 Mb/s	Cat 3	100 m
VG-ANYLAN	100 Mb/s	Cat 3	100 m+
100BASE-FX	100 Mb/s	mm fiber	2000 m
100BASE-SX	100 Mb/s	mm fiber	300 m
1000BASE-T	1000 Mb/s	Cat 5/6	100 m
1000BASE-LX	1000 Mb/s	mm fiber	550 m
		sm fiber	5000 m
1000BASE-SX	1000 Mb/s	mm fiber	500 m
10GBASE-T	10 000 Mb/s	Cat 6A	100 m
10GBASE-SR	10 000 Mb/s	mm OM3	300 m
10GBASE-LX4	10 000 Mb/s	mm OM1/2	300 m
10GBASE-LR	10 000 Mb/s	sm	10 000 m
10GBASE-EW	10 000 Mb/s	sm	40 000 m

## Quiz time 19

In each case, choose the best option.

### 1 Starting with the smallest, the types of networks are:

- (a) LAN, MAN, WAN
- (b) MAN, LAN, WAN
- (c) LAN, WAN, MAN
- (d) WAN, MAN, LAN

### 2 A token is:

- (a) a small gift
- (b) an electronic code used in ring topology
- (c) a computer or printer connected to a LAN
- (d) a design of a network suitable for a campus

### 3 A print server:

- (a) is another name for a file server
- (b) is a low quality printer that is supplied to each member of staff

- (c) handles the printing requirements of a network
- (d) is a series of modems

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**4 A central hub is found in:**

- (a) ring topology
- (b) star topology
- (c) a bicycle wheel
- (d) bus topology

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**5 Tree topology:**

- (a) uses less cable than bus topology
- (b) is exactly the same as bus topology
- (c) requires a hub
- (d) cannot be used with optic fiber



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## Some final thoughts

### **Sitting in the stream**

One problem with learning any technology based subject is that we can never say the job's done. We close our eyes for a moment then look up to find that technology has galloped off into the distance.

What is the best way to learn a language? The answer is obvious – go and live in a country where they speak it and be immersed in it. This is called *sitting in the stream* and applies equally well to any subject and is by far the easiest way of learning about fiber optics, or indeed, anything else.

We simply have to track down sources of anything about our chosen subject and let it trickle past in a gentle stream of information. With no effort at all, some of it will 'stick' whether we apply ourselves or not.

### **Generating a stream**

#### **Exhibitions**

Go to any fiber optic exhibition. Wander around, preferably with a companion, looking at anything of interest and picking up leaflets and catalogs. Attend any demonstrations or seminars. Don't worry about all the words that mean nothing at all – they don't matter. We are not sitting an exam. We are just splashing around in a stream. Bring all the information home and read every word of it, even the adverts – they are an important source of information and are guaranteed to be up to date.

## **Catalogs**

Catalogs are invaluable. They contain lots of information about the products and their specifications. They should be dipped into whenever a few seconds are going spare.

## **Magazines**

Read all magazines that have any articles on fiber optics. There are several publications dedicated to fiber optics and a few more to cabling in general which have many features on fiber.

## **Training courses**

Short courses are available from colleges, universities and industrial training companies. These courses are invaluable since they provide hands-on experience. Read the course information carefully to ensure that it will do what you want. What is the balance between theory and practice? At what level is the theory pitched?

Bearing in mind that it is the practical work that will probably be the main attraction, we need to ask some questions such as: how many people are going to attend the course and how many pieces of equipment, e.g. fusion splicers, are there available? It's no good going on a course and finding that most of the time is spent waiting around to use the equipment. Demonstrations are useful but are no substitute for making your own mistakes.

## **The web**

Every manufacturer maintains their own websites with numerous free downloads of catalogs, 'white papers', datasheets, etc. Most of the specialist magazines dealing in this subject have an electronic version on their websites.

Some of the major manufacturers worth looking up on Google are: ADC Krone, Belden/CDT, Commscope Systimax, Belden/CDT, Brand-Rex, Draka, General Cables, OCC, Pirelli, Tyco Pinacl, [www.ThePhysicalLayer.com](http://www.ThePhysicalLayer.com).

## **Have you heard of BICSI?**

If you work in the fiber optics industry or intend to, then this section will be worth a few minutes' read.

In the last few decades, fiber optics has developed from a curiosity into a multi-billion worldwide industry. As new industries expand, the pioneers discover their own techniques to meet the technical problems that they face on a day-to-day basis. As we would expect, some of these ideas are really good and some are little short of disastrous.

## **So, what is BICSI?**

In 1974, an association called the 'Building Industry Consulting Service International' was established. Thankfully, it has since changed its name to

BICSI. It has spread rapidly from its US origins to 82 countries with more than 20 000 members.

### **What's so good about it?**

- 1 It is a not-for-profit organization so it's not designed simply as a way to convert your income into someone else's income.
- 2 It is a telecommunications association, which means that it encompasses the whole range of design, installation and maintenance of both fiber and copper systems. This is important since installations inevitably involve both media.
- 3 It is of great benefit to its members and the customers. It is a rare example of a real win-win situation.
- 4 It collects together good design, working practices, and solutions to technical problems.

### **Why is it good for its members?**

As well as providing an efficient way of spreading the good ideas and warning of the dangers of the others, it provides a range of qualifications that are meaningful.

We all meet professional qualifications. I've got one myself. It's a very impressive certificate demonstrating my ability to maintain radar installations. This is supposed to prove my ability to offer advice, install and maintain a radar system, but does it? It might, but it shouldn't. Many years ago I was competent, actually pretty good, at radar technology, but that was many years ago. I have not touched radar since, but I am still qualified.

On the other hand, BICSI qualifications are valid only for three years and can only be renewed after proving that the holders are keeping abreast with developments and are moving ahead with their knowledge. The requirements are very specific and cannot be by-passed by general statements like 'I have read several magazines in the last three years'.

A BICSI qualification is impressive when job hunting in this field and you can take the first step on the BICSI ladder with little or no experience in the industry. The examinations are based on knowledge contained in their manuals, which are very comprehensive, well produced and easily read – a rare combination.

BICSI also ensures that all members are kept up to date with new developments.

### **Why is it good for customers?**

They can be certain that they get just what they expect. Whether it be an installer or a designer of a complete system, they can be sure that the person who turns up will actually be able to do the job.

BICSI specifies good design and working methods that provide a uniform and proven way of providing a telecommunication system. By installing to a known standard, this reduces time, cost and mistakes when it comes to extending or repairing the installation.

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